Tisch Environmental, Inc.

Series 230
High Volume Cascade Impactors
Multi-Stage Particulate Size Fractionator

Rev1. 8/2004

OPERATIONS MANUAL

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PREFACE

Tisch Environmental, Inc. is a third generation family owned business. The owners Wilbur J. Tisch and James P. Tisch have been involved in the High Volume Air Pollution field for the last 20 years. Started in March of 1998, they would like to welcome you to their company.

The intent of this manual is to instruct the user with unpacking, assembly, operating and calibration techniques. For information on air sampling principles, procedures and requirements please contact the local Environmental Protection Agency Office serving your area.

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1. INTRODUCTION

This introduction manual applies to all series of Tisch Environmental High Volume Cascade Imapctors as well as to other special adaptations and combinations. The attached product sheet gives the specifications of the 230 Series High Volume Cascade Impactors. Series 230 is the finest High Volume Cascade Impactor commercially available. Compared to multiple circular jet designs, it has eight times the sensitivity, the sharpest cut-off, the lowest internal losses, and is easiest to use.

High Volume Cascade Impactors measure the size distribution and respirable mass fraction of airborne particles in outdoor and indoor environments. They attach to most standard High Volume Air Samplers, including: Tisch Environmental, Sierra-Andersen, General Metal Works, BGI, Bendix-Unico, Staplex, Weather Measure, Curtin Scientific, Research Appliance and other. If your Hi Volume sampler is other than Tisch Environmental or General Metal Works, check with Tisch Environmental to insure proper adaptation. Series 230 Impactors operate in accordance with procedures established by the U.S. Environmental Protection Agency (CFR 40, Part 50.11, Appendix B, July 1, 1975, Pages 12-16) and ASTM Specification D2009.

An important advantage of the Series 230 High Volume Cascade Impactor is that they operate at a nominal flow rate of 40 scfm (standard cubic feet/minute @760mmHg and 25C), which meets the specifications of the U.S. EPA. If desired, it can operate as low as 20 scfm and as high as 50 scfm. Other High Volume Cascade Impactors operate at substantially lower flow rates and do not compare as well with standard High Volume Air Samplers operating at the EPA specified rate of 40 to 60 scfm. The Model TE-236 Six-Stage High Volume Cascade Impactor operates at a flow rate of 20 scfm only. The small width (0.006”) of the last Impactor stage, Stage 6, causes a relatively high pressure drop which precludes operation at a flow higher than 20 scfm.

By virtue of the basic operating principle of the Impactor, particles are sized by their <u>aerodynamic size</u>. Aerodynamic size, rather than geometric size, determines the trajectory of the particle in a gas stream because it accounts for all three major aerodynamic factors: size, shape and mass density. The direct measurement of Cascade Impactors is “equivalent aerodynamic diameter,” defined as the size of a spherical particle of mass density 1 gm/cc which has the same terminal settling velocity as the sampled particle. In contract, microscope and light scattering methods of particle sizing do not account for mass density and aerodynamic size. Aerodynamic size is the most important size in particle work because it determines the penetration of particles in the human lung, the particle collection efficiency in pollution control equipment, and the transport and diffusion of particles in the ambient air.

Series TE-230 High Volume Cascade Impactors greatly increases the brush and motor life of High Volume Air Samplers because of operating flow rate normally is less than the flow rate at full voltage. They are designed to minimize particle reintrainment (or blow-off), to minimize inter-stage losses, and to maximize sharpness of cut-off. Appendix A describes the methodology used to optimize their design.

2. MODELS

TABLE 1
PARTICLE SIZE CUT OFF & CUNNINGHAM SLIP

	@ 40 scfm		@ 20 scfm		
STAGE NO.	PARTICLE SIZE RANGE Dp,50 * (in microns)	CUNNINGHAM SLIP FACTOR **	PARTICLE SIZE RANGE Dp,50 * (in microns)	CUNNINGHAM SLIP FACTOR **	GEOMETRIC STD. DEV.
1	7.2 to ∞	1.02	10.2 to ∞	1.02	1.34
2	3.0 to 7.2	1.06	4.2 to 10.20	1.04	1.50
3	1.5 to 3.0	1.11	2.1 to 4.2	1.08	1.49
4	0.95 to 1.5	1.17	1.3 to 2.1	1.13	1.50
5	0.49 to 0.95	1.33	0.69 to 1.3	1.24	1.50
6	N/a	n/a	0.39 to 0.69	1.42	1.50
Hi-vol Filter	0.0 to 0.49	n/a	0.0 to 0.39	n/a	n/a

* (Dp,50) The cut-points are experimental values obtained from the calibration with mono-disperse aerosols described in Reference 2.
** C Cunningham slip correction factor taken from Appendix B.

Four standard models of the 230 series are available, all of which similarly adapt to standard High Volume Air Samplers.

Model TE-236: Stages 1,2,3,4,5, and 6
Model TE-235: Stages 1,2,3,4 and 5
Model TE-234: Stages 1,2,3 and 4
Model TE-231 Single Stage “Fine” (40CFM $PM_{2.5}$ Single Stage)

Other combinations of stages are available on request. All stages are available individually. Please consult the Tisch Environmental factory.

3. DESCRIPTION

3.1. IMPACTOR STAGES

The operating principles and cross-sectional view of the High Volume Cascade Impactor is shown in the attached product sheet. The Impactor stages consist of aluminum plates with outside dimensions of 6 inches x 7 inches. All Impactor plates are clear anodized to prevent corrosion and reduce possible sticking of collection substrates to the plates. Impactor stages 2,3,4,5 and 6 have 10 parallel slotted impaction jets. Stage 1 has 9 slots to eliminate end effects. All slots have center lines one-half inch apart. Table 2 below gives the parameters for the impactor stages. The particle cut-off size for each impactor stage are given in table 1. The highest cut-off size is nominally 10 microns. This stage essentially collects larger mechanically generated particles. The final two stages, stage 5 and 6 gives data points in the very important sub-micron range. The cut-off of the remaining stages are selected logarithmically, a factor of approximately two apart. The methodology used in selecting the design parameters show in table 2 is given in Appendix A.

TABLE 2
HIGH VOLUME IMPACTOR STAGE PARAMETERS
(@ 40 scfm, 25°C and 760 MM Hg)

STAGE NO.	SLOT WIDTH (w) inches	# OF SLOTS	TOTAL LENGTH SLOT Inches	THROAT LENTH (T) inches	JET TO PLATE DISTANCE (S) inches	T/w	S/w	SLOT REYN-OLDS # V2W/δ	JET VELOCITY (V) m/sec
1	0.156	9	43.5	0.250	0.125	1.60	0.80	2245	4.3
2	0.064	10	48.8	0.050	0.075	0.78	1.17	2005	9.38
3	0.036	10	48.8	0.050	0.075	1.39	2.08	2005	16.7
4	0.018	10	48.8	0.050	0.075	2.78	4.16	2005	33.4
5	0.010	10	48.8	0.050	0.075	5.00	7.50	2005	60.1
6*	0.006	10	48.8	0.050	0.075	8.33	12.5	602	50.1

* 20 scfm only

Special $PM_{2.5}$ Single Stage Impactor. Model TE-231

STAGE NO.	SLOT WIDTH (w) inches	# OF SLOTS
Fine	0.050	10

3.2. COLLECTION SUBSTRATES

Collection substrates for the 230 series Cascade Impactors are available from Tisch Environmental, Inc. Type A glass fiber filter media is the most commonly used material for collection substrates. Deposition of the particles into the glass fiber lattice improves particle retention and reduces possible re-entrainment. Whatman® 41 cellulose-base filter media and metal foils can also be used as collection substrates. The substrates are thin flat sheets with 10 perforated slots exposing the slots in each stage. Particles passing through the slotted jets in the impactor stages impact on the collection substrates and are thereby deposited or collected. The collection substrates also act as the vacuum seal between impactor stages. Collection substrates provide a most convenient method for particle collection in contrast to using the heavy impactor stages themselves as the collection substrates and greatly reduces the cost of back-to-back tests by eliminating the need to purchase extra sets of impactor stages. The collection substrates also permit easy storage and subsequent chemical analysis.

The collection substrates are only 5.625 inches x 5.375 inches and easily fit standard micro-balances without folding the paper. Their small size also results in a very low tare weight (approximately 1.2 gram) and minimal adsorption of gaseous pollutants thereby increasing measurement accuracy.

To prevent re-entrainment, we recommend the use of a thin layer of silicone grease on all metallic collection substrates or on the Impactor stages themselves if they are to be used as the collection substrates. The coating on each stage should be at least as thick as the diameter of the particles that will be collected on the stage. The thickness of the coating on stages 1 and 2 should not exceed about 100 microns (0.044 inches). For the remaining stages the coating thickness should be in the 1 to 10 micron range.

3.3. BASE PLATE

The Impactor stages stack on top of the clear anodized aluminum base plate and are secured thereto by means of the two 1/4-20 studs with thumb-screws. The base plate is designed to fit on top of the 8 inch x 10 inch filter holder in standard High Volume Air Samplers. The filter in the standard High Volume Air Sampler serves as the back-up filter for the cascade impactor and collects all particles smaller than the cut-off size of the last Impactor stage.

3.4. FILTER CARTRIDGE

All Tisch Environmental, Inc. Impactors are furnished with the Model TE-3000 8 inch x 10 inch Filter Media Holder, Filter Paper Cartridge. The Cartridge is screwed to the Impactor base with thumb-screws and permits removal of the entire Impactor filter assembly to a convenient location for disassembly and analysis.

4. ASSEMBLY

The entire assembly fits on the 8 inch x 10 inch filter holder on a standard High Volume Air Sampler. The existing 8 inch x 10 inch filter functions as the final stage. First the filter is placed down, rough side up, on the stainless steel screen. Next, the large base plate is placed down over the filter paper. The rubber gasket (P/N TE-5018) on the bottom of the base plate fits around the periphery of the filter in a manner identical to the existing filter holder frame. The black plastic thumb-nuts on the High Volume Air Sampler are tightened to hold the base plate down. A collection substrate is placed down on the base plate. NOTE: It is recommended to lightly tap each glass fiber collection paper before inserting it into the Impactor to shake off any excess fibers. Then, place subsequent Impactor metal stages down over the two treaded studs, starting first with the highest number stage. The Impactor stages are assembled with their number in the upper right-hand corner. The slots on successive impactor stages are staggered so that each slot is above an impaction plate, not above another slot. With clean hands, the collection substrates are carefully placed between the collection plates so that the slots are exposed. The collection substrate is centered over the slots, rough side up. The collection substrates for all stages are identical. If ambient humidity is high and glass fiber collection paper is used as the collection substrate, it may adhere to the impactor stages. Although this phenomenon cannot be eliminated entirely, a very slight amount of baby powder or talcum powder can be used to “condition” the impactor stages sealing edges. Of course, all excess powder must be removed before the test.

The knurled nuts holding the assembly together are hand tightened lightly. Only a light torque is required because the pressure drop through the instrument adequately seals it. Excessive tightening may cause fractionation of glass fiber collection paper, which then can adhere to the Impactor plates.

5. CALCULATION OF PARTICLE SIZE CUT-OFFS

The operating flow rate of all 230 series is 40 scfm, except for the Model 236 which operates at 20 scfm. Section 2.0 gives the Impactor cut-off sizes and Cunningham slip correction C for flow rates of 20 and 40 scfm, a particle mass density of 1 gm/cc, and standard temperature and pressure conditions (25°C and 76 mm Hg). In general, the particle size cut-off Dp,50 at 50% collection efficiency for spherical particles is:

$$Dp{,}50 = \sqrt{St}\; w \sqrt{\frac{9\;\eta\;L}{C\;Pp\;Q}}$$

Where: $\sqrt{St}$= the square root of the Stoke's Number, which depends on jet throat length, and jet Reynold's Number

- w = slot width, cm
- η = gas viscosity (1.8×10^{-4} gm/cm. Sec @ 25C, 760 mm Hg) gm/cm. sec.
- L = slot length, cm
- Pp = particle mass density, gm/cc.
- C = Cunningham slip correction (nominally C=1 for large Dp)
- Q = flow rate

The above calculation is used to calculate the particle size cut-off for flow rates other than 20 or 40 scfm and for particle mass density other than 1 gm/cc. Normally temperature and pressure effects are negligible. The flow rate can be increased to get smaller cut-off size and decreased to get larger cut off size.

The flow rate through the High Volume Cascade Impactor is measured in the same way the flow rate through the typical High Volume Air Sampler is measured: (1) with a manometer, if the High Volume Air Sampler has an exit orifice, or (2) with a calibrated rotameter provided with the High Volume Air Sampler. The flow rate should be accurately calibrated using an orifice calibrator such as the Tisch Environmental, Inc. Model TE-5028 or TE-5025 Calibration Kits. EPA procedures should be followed per CFR 40, Part 50.11, Appendix B, July 1, 1975, pages 12-16.

Unaccountable flow rate changes will diminish the sharpness of the particle collection efficiency. Maintaining the high accuracy inherent in the High Volume Cascade Impactor requires known, constant flow rates. Tisch Environmental Model TE-300-310 and new Flow Commander™ Constant Flow Controllers maintains the flow rate through the Impactor precisely constant over the selectable range of 15 to 50 scfm and provides correction for filter loading and changes in line voltage, ambient temperature, and ambient pressure. It is recommended for use in the TE-230 Series Impactors.

6. SAMPLING

The High Volume Cascade Impactor can be effectively operated indoors or outdoors, with and without a shelter, and in any position, although the upright position is normal. In outdoor ambient air, 24-hour operation is normal. In heavy dust concentrations, such as found in occupational environments operation for 8 hours or less is common. If more than one sample is required for two continuous time periods, two or more, impactors are recommended. In general, the sampling time period should be long enough to collect at least 10 mg of particulate on each Impactor stage.

7. OPERATING PROCEDURE

A complete operating procedure is given is Appendix C.

8. WEIGHING

The primary measurement is the weight of the particle deposition per Impactor stage, measure as the difference in weight of the collection substrate before and after sampling. Weighing is conducted in a clean laboratory environment with a relative humidity of 50% or less. Collection substrates normally are allowed to equilibrate with the laboratory environment for approximately 24 hours before weighing. The collection substrate is placed in a numbered envelope. After sampling, the collection substrate is folded in half with the two “dirty” halves touching. Any standard laboratory “Semi” microbalance with a sensitivity of 0.1 milligrams or better should be used. A major advantage of the High Volume Cascade Impactor is the low tare weight of the collection substrate, which greatly increases measurement sensitivity. The tare weight is about 1.2 gm. Appendix D shows an example calculation.

If desired, the Impactor stages themselves can be used as the collection surfaces. They are relatively lightweight (approximately 155 grams) and can be used as the collection surface for the last stage since the base plate normally is too large and heavy for weighing.

9. DATA PRESENTATION

Particle size distributions are normally plotted cumulatively on log normal graph paper. In this format, the total mass W_i in all stages, including the back-up filter, is added up and the percent less than the 50% cut-off size Dp,50 for each stage plotted against Dp. In the particle size distribution field, the size typically is plotted in terms of EAD (equivalent aerodynamic diameter) or the size of a spherical particle of density 1 gm/cc which has the same terminal settling velocity as the sampled particle. On log-normal paper the particle size distribution of emissions sources often is close to a straight line. Once the cumulative particle size distribution is plotted, the two major parameters of particle size distribution can be determined: (1) the “mass mean diameter” Dp,50, the particle size at 50% collection efficiency; which is an over all measure of the size of the particles, whether large or small and (2) the “geometric standard deviation” Pg, the ratio Dp,50%/Dp,16%—which is a measure of the “spread” in the particle size distribution (if Pg > 1, the aerosol is mono-disperse, typically Pg > 1). Alternatively, the particle size distribution can be presented as the percentage of particles in the size range captured by each stage:

$$W_i / W_{tot} \times 100 \text{ (in percent)}$$

Where: W_{tot} = sum of particles collected on all stages, including the filter stage

This can be presented as a bar chart where W_i is taken as the mass of particles in size range $(Dp,50)_i$ to $(Dp,50)_{i-1}$. Appendix D gives an example calculation. Figure 1 shows the resulting cumulative particle size distribution on log-normal paper.

Another method of data presentation similar to the above is to plot dW_{tot}/dlog Dp versus Dp on log-log paper. This graph is essentially the derivative of the cumulative size distribution.

Respirable Mass Measurement
In general, the respirable mass M_R is determined by combining the respirable mass retention efficiency e(Dp) with the particle mass size distribution m(Dp) obtained with the High Volume Cascade Impactor:

$$M_R = \int_0^{\infty} m(Dp)\, e(Dp)\, dDp$$

Where Dp is the particle size. Respirable mass is determined with high accuracy using this method, and, obviously, the more points on the size distribution, the more accurate the measurement.

The American Conference of Governmental Industrial Hygienists (ACGIH) and the Atomic Energy Commission (AEC) have established the widely used standard curve for the efficiency of retention of particles in the human lung, shown is Figure 2. Contact the factory for the appropriate stages to make such measurements. The Model 231R is selected to fit this curve. In particular, the Model TE-231R has a particle size cut-off of 3.5 microns.

10. CARE AND MAINTENANCE

The TE-230 Series Impactors are anodized aircraft aluminum for corrosion and soiling resistance. Nonetheless, care should be taken to not excessively touch the Impactor stages, because fingerprints and skin oils can partially clog the slots, add erroneous weight, and cause corrosion. If the Impactor stages are dirty, clean with alcohol or water and a clean cloth. After a few tests, hold each stage up to the light to see if the slots are partially blocked. If so, clean by washing in a detergent water solution or by using an ultrasonic bath and then rinsing and drying thoroughly. Clogged slots should be cleaned with shim stock because small fibers or dirt in the slots, particularly on the downstream side, can distort the particulate deposition.

11. PERFORMANCE DATA

The Model TE-235 has been carefully calibrated[1] with monodisperse liquid oleic acid particles plus 10% uranine fluorescent dye. The particles are generated with a monodisperse aerosol generator. Each stage and the back up filter were analyzed using a fluorometer for collection efficiency and for interstage losses. Figure 3 gives the experimental collection efficiency curves for each Impactor stage for Type A glass fiber collection paper. Section 2.0 gives the mass median diameters and geometric standard deviations for Figure 3. The mass median diameters for coated solid collection substrates are very close to those for the glass fiber collection paper. Figure 4 gives the interstage losses for each stage and for the entire Impactor. Total interstage losses for a typical outdoor aerosol as shown in Figure 1 is only about 5.5%. This total loss percentage is significantly lower than the maximum loss shown in Figure 4 because particle mass between 1 and 4 microns is only a fraction of total particle mass for typical aerosols.

12. REFERENCES

1. Marple, V.A. and Liu, B.Y.H., “Characteristics of Laminar Jet Impactors,” Environmental Science and Technology, Volume 8, November 7, July 1974, pages 648-654.
2. Willeke, K., “Performance of the Slotted Impactor,” AIHAJ, pages 683-691, September, 1975.

Figure 1
Typical Cumulative Particle Size Distribution

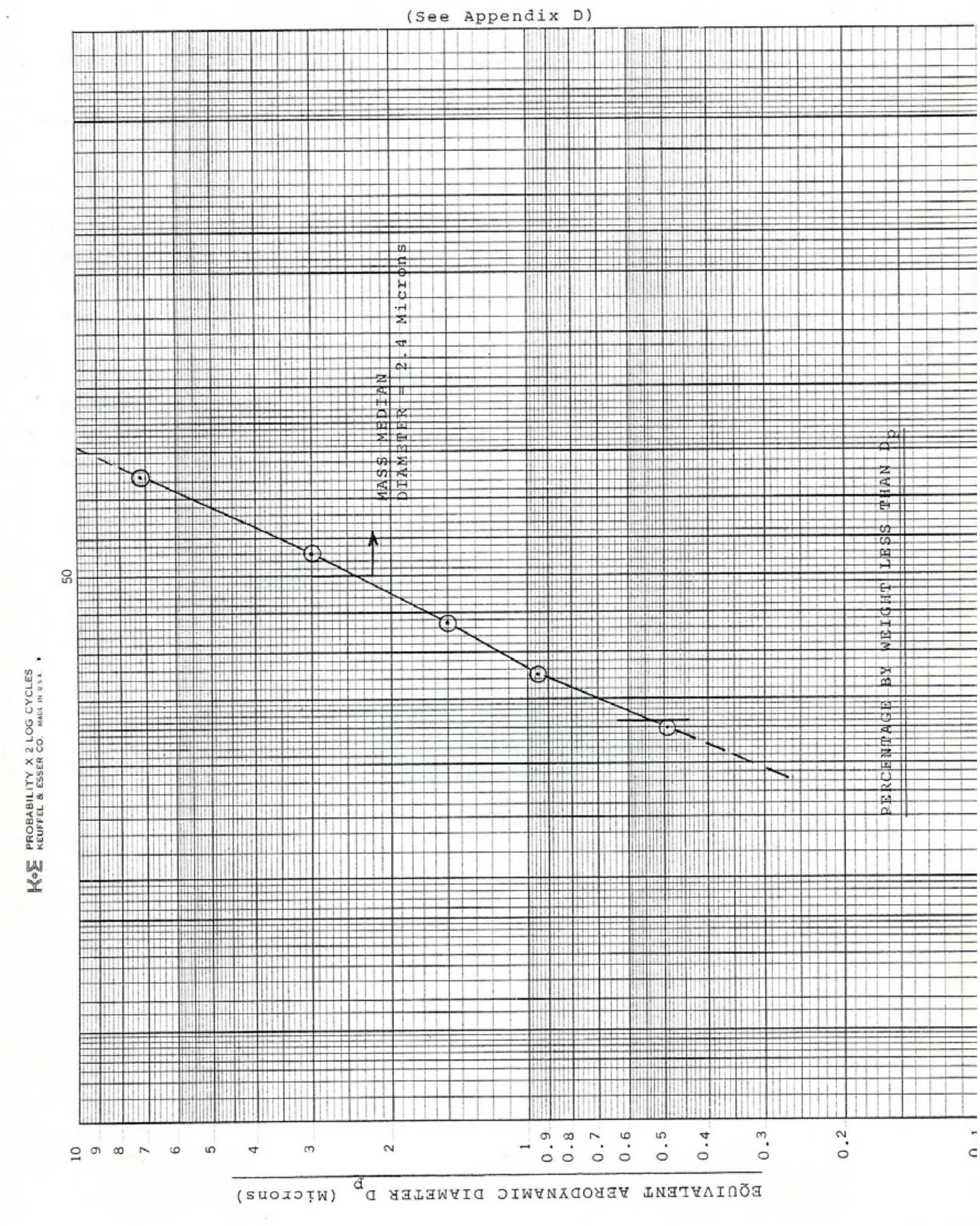


Figure 2
ACGIH Respirable Retention Efficiency Curve

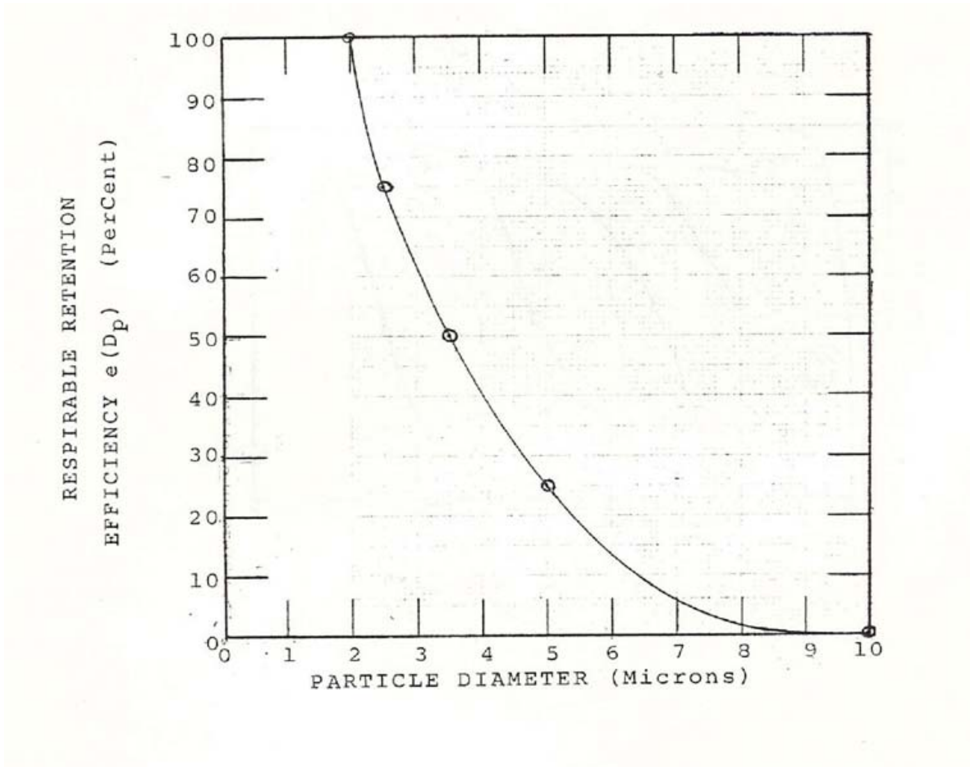


Figure 3
Experimental Collection Efficiency Curves
Gelman Type A Glass Fiber Paper

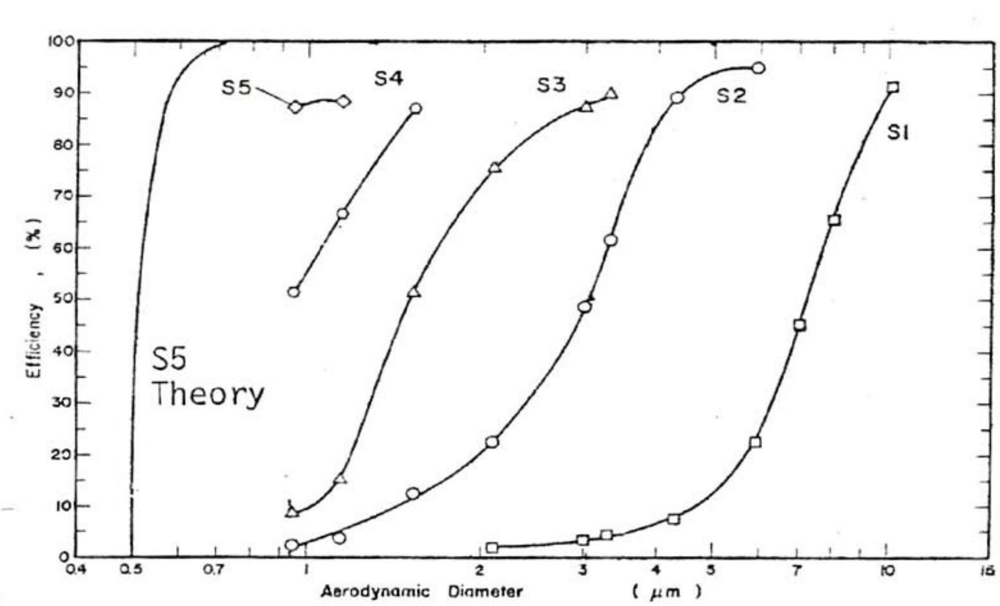
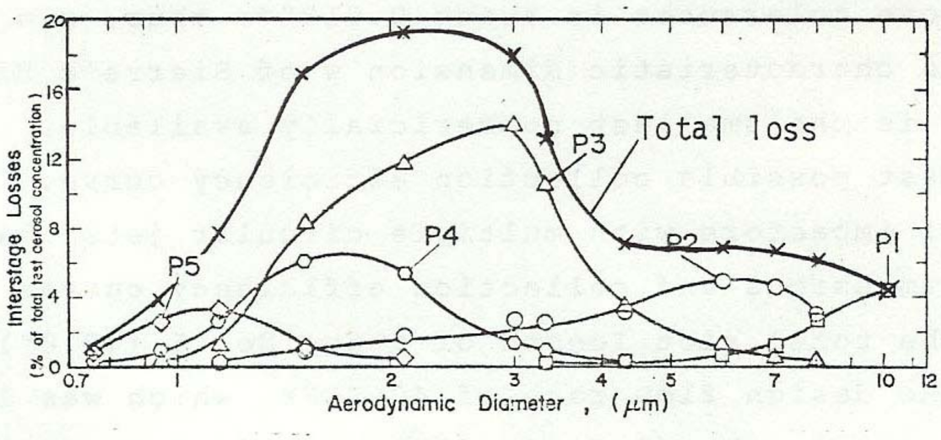


Figure 4
Interstage Looses Expressed as percentage of Total Test Aerosol Concentration



Appendix A

Design Methodology

Considerable effort was made to optimize the performance of the Tisch Environmental High Volume Cascade Impactors. The TE-230 Series is designed to maximize the area of the particulate deposit and to minimize the jet velocity. Satisfaction of the re-entrainment requires that the jet velocity not exceed approximately 60 m/second and be the minimum possible for each sampling stage. The maximum area and minimum jet velocity is achieved by using the smallest slot width practicable for the particle cut-off desired. As a practical matter, the minimum width slot that can be machined with close tolerances is about 0.100”*, thus, w = 0.010” for Stage No. 5. The characteristic dimension 2 of Tish Hi Vol Impactor therefore is the smallest commercially available. This gives Tisch the sharpest possible collection efficiency curve. The total slot length of Stage No. 5 (48.8”) is then chosen to pass the design flow rate of 40 scfm, which was in turn chosen because it falls within the 40 to 60 scfm specified by the US EPA. For the remaining stages, the slot length is as long as possible within practical physical constraints.

Marple1 has shown that the jet-to-plate distance ration W/W for rectangular jets should be greater than approximately 1.0 for a stable cut-off. As shown in Table 3, this condition is met in the TE-230 series. High values of the throat length ratio T/w are desirable for rectangular jets to damp out possible vorticity. The TE-230 series has the highest values of T/w practically achievable (see Table 3). Jet Reynolds numbers are ideally about 30001, but should not be below about 500. This condition is also met in the model TE-230 series.

* Stage No. 6 of the Model TE-236 has a slot of 0.006”.

Appendix B

Calculation of Particle Size Cut-Off

A TE-201 Marple Impactor Slide-Rule Calculator can be used as an accessory device to determine the particle size cut-offs for conditions other than those provided in Section 2.0

The Marple Impactor Calculator is an easy to use circular slide rule based on the proven impactor theory of Professor V. A. Marple (See Reference 1).

TABLE B-1
REFERENCE PARAMETERS [1]

STAGE NO.	n	Slot width, nw (cm)	$\frac{1}{n} 3 \frac{L}{W}$	Flow Rate per Slot [2] (LPM)	D_p, 50 (microns)	$\sqrt{C}$ x D_p 50 [3] (microns)	$\sqrt{St}$ [4]
1	1	0.396	31.0	125.8	7.2	7.3	0.60
2	1	0.163	76.1	113.2	3.0	3.1	0.58
3	1	0.0914	135.7	113.2	1.5	1.56	0.52
4	1	0.0457	271.3	113.2	0.95	1.03	0.69
5	2	0.0254	61.0	113.2	0.49	0.57	0.69
6	2	0.0152	102	56.6	0.41	0.48	0.69

Notes:

(1) for glass fiber collection substrates, 40 CFM, particle mass density of 1f/cc, 25ºC, and 1 atmospheric pressure
(2) at 40 CFM, except for Stage 6 which is at 20 CFM
(3) From Fig. 3 of Model 201 Instruction Manual (P=1 atm.)
(4) Note that $\sqrt{St}$ will not be exactly the same as the theoretical values given in Figs. 1 and 2 of the Model 201 I.M. because glass fiber collection substrates have slightly different cut-offs than the solid collection substrate assumed in the theory.

The square root of the Stoke's number $\sqrt{St}$ given in Table B-1 will be the same for any operating condition. Since the pressure drop through the cascade impactor is relatively small, the pressure for all stages is taken as P=1 atmosphere.

For steps 5 and 6, the slot width w is out of range of the scale. From the equation for "Rectangular Impactors" given on the face of the circular slide rule, we see that if we multiply the slot width by 2 to bring it within the range of the "w" scale and also divide L/W by 8 to compensate for this change, the Stoke's Number St will remain the same. These values are also shown in Table B-1.

An example calculation for the Model 235 follows. Assume that the total flow rate is 30 CFM, and the particle density is 2.5 g/cc. The particle size cut-offs are given in following Table B-2:

TABLE B-2
EXAMPLE CALCULATION

GIVEN					CALCULATED	
Stage No.	Slot Width (cm)	L/W	Q Per Slot (LPM)	$\sqrt{St}$	$\sqrt{C}\ D_p$ (1) (microns)	D_p (2) (microns)
1	0.396	31.0	94.4	0.60	5.3	5.2
2	0.163	76.1	84.3	0.58	2.27	2.2
3	0.0914	135.7	84.3	0.52	1.15	1.1
4	0.0457	271.3	84.3	0.69	0.88	0.80
5	0.0508	61.03	84.3	0.69	0.414	0.34

Notes:

(1) From circular slide rule
(2) From Fig. 3 of Model 201 Instruction Manual (P=1)

Appendix C

Operation and Data Reduction Procedure
Model 230 Cyclone Preseparator and Series 230 High Volume Cascade Impactor*

Unloading

1. Carefully remove the entire cyclone and cascade impactor from the hi vol without tipping or jarring. Carry to a building or vehicle where the units can be serviced out of the elements.

2. Using distilled water, rinse out the cyclone. Put washings in a sample jar. See Model 230CP Instruction Manual for detailed procedure.

3. Beginning with the first impactor stage, carefully remove the collection substrates, one at a time, from the cascade impactor, fold each in half, and place in an individual 6" x 9" envelope (do not seal). On the outside of each envelope, write the following information: Station name, hi vol serial number, date of run, stage number, collection substrate number, flow rate, and any pertinent remarks.

4. Next, lift the base plate from the 8" x 10" filter and carefully remove the filter from the screen, handling the edges only. Fold the filter in half (widthwise) and place in a 6½" x 9½ " envelope. Record necessary information on the outside of the envelope.

5. Complete the Data Sheet (attached), including today's date and your initials.

6. Mail collection substrates, filters, and cyclone sample-jars, together with the original copy of the cyclone Data Sheets, to the laboratory each week. Use a mailing container supplied by the laboratory and ship "Priority Parcel Post."

7. Once per month, cleanse the cascade impactor plates, plus all inner surfaces of the cyclone with acetone.

Reloading

1. Start a new Data Sheet. Data Sheets are to be completed in duplicate. Fill in date of sample, hi vol serial number, and collection substrate number for each of the five cascade stages plus the 8" x 10" filter.

2. Place the clean, pre-weighed and numbered 8" x 10" filter, numbered side down, on the stainless steel screen.

3. Place the large base plate down over the 8" x 10" filter so that the rubber gasket on the bottom of the base plate fits around the periphery of the filter. Tighten the thumb nuts on the high volume sampler to hold the base plate down.

4. Place a slotted collection substrate on the base plate, numbered side down, and align the slots in the collection substrate with those in the plate below. Be sure the slots in the plate below are not covered by the collection substrate.

5. Next, place the last impactor state (Stage 5) over the two threaded studs so that the stage number is in the upper right hand corner.

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* This procedure is based on information provided to Sierra Instruments compliments of:
TRC, The Research Corporation
125 Silas Deare Highway
Wethersfield, CT 06109

6. Place a collection substrate over the plate, numbered side down, so that the slots are centered over those in the plate below.

7. Repeat Steps 5 and 6 for impactor stages 4,3,2, and 1 in that order.

8. Replace the washers and knurled thumb nuts on the threaded studs and hand-tighten to hold the assembly together.

9. Return the cascade impactor to the high volume sampler, taking care not to jar the assembly during transit. Reattach the cascade impactor to the hi-vol.

10. Start up the hi-vol and allow the flow to stabilize. Set the hi-vol to run at a flow of 40 CFM. Set the timer/programmer.

Tisch Hi Vol Impactor
Field Data Sheet

Analysis No. ______________________ Sampling Site ______________________

Client ______________________ Sample Date ______________________

Contract No. ______________________

Sample Description		Flow (CFM)				Hrs. Run	Mg. of Particulate	μg/M³ Part.
Collection Device	Jar/Filter No.	ON	MID	OFF	AVG.			
Impaction Stage 1			n / a					
" Stage 2			n / a					
" Stage 3			n / a					
" Stage 4			n / a					
" Stage 5			n / a					
8 x 10 HiVol Filter			n / a					

Comments ______________________

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____

____

Results Calculated By ______________________ Date ______________________

Independent Review By ______________________ Date ______________________

Data Sheet

Station ______________________ Date of Sample ______________________

Total on Time ______________________

Technician's Initials ______________________

Hi-Vol S/N ______________________ Today's Date ______________________

Cyclone Sample – Jar No.	
5.6" x 5.4" Stage 1 Filter No.	
5.6" x 5.4" Stage 2 Filter No.	
5.6" x 5.4" Stage 3 Filter No.	
5.6" x 5.4" Stage 4 Filter No.	
5.6" x 5.4" Stage 5 Filter No.	
8" x 10" Hi-Vol Filter No.	

	Start-Up	Ending
Date/Time	/	/
Gauge Reading (inches of H_20)		
Flow (CFM)		

Remarks ______________________

Appendix D

Example Calculation of Data Reduction (Model 235)

Stage No.	Tare Weight (g)	Final Weight	Net Weight (mg)	%	Cumulative % less than	EAD* (microns)
1	1.2000	1.2100	100	25.0	75.0	7.2
2	1.2100	1.2175	75	18.8	56.2	3.0
3	1.2005	1.2080	75	18.8	37.4	1.5
4	1.1900	1.1950	50	12.4	25.0	0.95
5	1.2010	1.2050	40	10.0	15.0	0.49
Filter	3.5000	3.5060	60	15.0	0	0
			400	100.0		

* We assume that Q=40 CFM, P = 1g/cc, T=25ºC, and P=1 atmosphere

The cumulative particle size distribution from the above calculation is given in Fig. 1. From this figure we get:

D_p, 50% = 2.4 Microns and

$$\sigma g = \frac{2.4}{0.53} = 4.5$$